

Phase I Project Summary

Firm: C3 Propulsion, a division of Streamline Automation LLC.

Contract Number: NNX13CS08P

Project Title: Power Generating Coverings and Casings

Identification and Significance of Innovation:

Ceramics, like BiTe, are the only thermoelectric materials used to harvest waste energy. They are heavy and rigid, therefore, only applicable to smooth geometries such as flat plates or cylinders. Ceramics do not have the ability to harvest vibrational energy into electrical power. Power Felt™, being a fabric-like material, can conform to any object that produces heat. Ceramics have a greater efficiency in power generation, but Power Felt™ being flexible will have a much greater area of contact, more than makes up for its lower power generating efficiency. During Phase I, the ability to generate power from Power Felt™ increased by more than an order of magnitude, added the ability to generate power from vibrational energy, and determined that the total power generated was greater than the sum of the thermopower and piezopower contributions. Although not complete, the Phase I program developed techniques that can be combined to develop a manufacturing process that will produce Power Felt™ at a lower cost and more consistently.

Technical Objectives and Work Plan:

The primary objective in Phase I was to demonstrate the scientific, technical, commercial merit, and feasibility of an innovative fabric covering that can harvest power from highly energetic environments.

The specific technical objectives of Phase I were:

- Demonstrate printing as an approach to the manufacture of appliques and plaques. This will demonstrate the ability to print test pieces with an internal interconnect system that allows for ease of use and single-unit applications.
- Demonstrate combined thermal and kinetic energy scavenging capabilities from these test pieces. The test plaques will be robust to puncture, scuffing, most solvents or scratching, and will provide power regardless of the direction of heat flow (hot to cold or cold to hot) or the form of mechanical energy encountered.
- Manufacture a 1-m² fabric after successful demonstration of the small pieces. The printed multi-module pieces will have a specific area density of approximately 50 grams/m² for Phase I. Testing this fabric will show that the overall power output will scale with area.
- Develop custom circuitry for eventual integration into the PowerFelt™ fabric that does not diminish the advantages inherent with the material. We will design this system for the collection, storage, and distribution of the harvested energy.

Technical Accomplishments:

The key technical accomplishments during the Phase I program are:

- Improvements in PowerFelt™ technology resulted in an increase of power output by an order of magnitude from only a thermal gradient.
- For the first time, PowerFelt™ produced power from both a thermal gradient and vibration simultaneously.
- The resulting power harvested from both thermal and vibrational waste energies was greater than the sum of both.
- A 1.5" x 2.0" piece of PowerFelt™ was tested successfully at Stennis Space Center's High Pressure Liquid Nitrogen facility, demonstrating power production at cryogenic temperatures.

NASA Application(s):

Our goal for this project is to mature PowerFelt™ from NASA's TRL 4 to TRL 6 by the end of Phase II. NASA can exploit this technology wherever thermal gradients and vibrations are present. Two potential applications at NASA Centers for PowerFelt™ are providing power to remote sensors around the facility and to supplement/eliminate batteries in experimental apparatuses at the test stands. Launch and space applications include supplemental/backup power for instrument and life support on manned, non-manned, and planetary exploration vehicles; satellites; instrument and life support on ISS; and instrumentation on sounding rockets and balloons.

Non-NASA Commercial Application(s):

DOD has numerous applications for power generating including minimizing the battery weight for ground troops; electronic gun controls; missile; guidance and control systems; NBC defense systems; submarines; surface ships; aircraft for electronics and life support; unmanned aerial vehicles; and aircraft for. It can also be used to many power communication devices. Applications to the civilian market are similar to those for NASA and DOD, that is to eliminate or reduce the need for batteries and incorporation of PowerFelt™ into clothing; cell phone holsters; tents; backpacks; conventional and hybrid vehicles, including the passenger compartment electronics; and power generation during emergencies.

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